# *ANACAPA ISLAND RESTORATION PROJECT*

## CHAPTER FOUR
## *ENVIRONMENTAL CONSEQUENCES*

### *Chapter Contents*

# Introduction

This chapter discloses the environmental consequences of implementing each alternative described in Chapter Two. The environmental consequences, or environmental effects will be categorized in three broad areas. The three categories of effects are direct, indirect, and cumulative. These "effect" categories will form the basis of the effects analysis in this chapter.

Direct effects, as defined by the Council on Environmental Quality, are those which are caused by the action and occur at the same time and place. Indirect effects are those which are caused by the action and are later in time or farther removed in distance. Cumulative effects are those that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

The cumulative impacts analysis has been narrowed down to two main issues, the potential repeated exposures of non-target species to the rodenticide and the cumulative impacts to seabirds that utilize Anacapa Island for breeding. This chapter forms the scientific and analytical basis for the relative comparison of effects presented towards the end of Chapter 3.

# Issue 1: Efficacy

## Introduction

This section of the analysis compares the different alternatives and how well they meet the purpose and need. The objective of this project is to remove 100% of the rat population from Anacapa Island. Therefore, the rodenticide of choice, and its delivery into the ecosystem, must offer the greatest probability of achieving success. The success of the eradication is dependent on the rodenticide chosen, the bait composition and its delivery into the ecosystem and awareness of the local conditions that could be exploited to maximize success. These factors will be analyzed for each alternative.

## The Rodenticide and Toxicological Properties

There are three rodenticides outlined in the alternatives. They are brodifacoum, bromadiolone (second generation anticoagulant) and diphacinone (first generation anticoagulant). All of these chemicals are anticoagulant rodenticides, which cause mortality to the target species through hemorrhaging (See Biochemistry below for further discussion). In general, the difference between the first and second generation anticoagulants is their acute toxicity to rats, the amount required to kill rats, and their ability to control a population of rats.

The acute toxicity of the rodenticides are presented in Table 7. Acute toxicity ($LD_{50}$) is defined as the amount of active ingredient (mg) per kg body weight, required in a single oral dose to kill 50% of a test population. Only the acute toxicity of brodifacoum is known to the target species, *Rattus rattus*. The other $LD_{50}$ data presented are based on Norway rat (laboratory rat) data that may not be representative for *Rattus rattus*. Following the pattern of toxicity for the lab rat across all three anticoagulants, brodifacoum is approximately twice as toxic as bromadiolone, and orders of magnitude more toxic than diphacinone. Although all the rodenticides are toxic to the target rat species, in practice, the rodenticides differ in their ability to kill the target species.

The rodenticides presented are classed as either "single feeding" or "multi-feeding" rodenticides. The first generation anticoagulant diphacinone is a "multi-feeding" rodenticide in

Table 7. Amount of bait required (g) for rats to reach one $LD_{50}$.

| | Active Ingredient (Rodenticide) | | |
|---|---|---|---|
| | Brodificoum 25 ppm<br>Alternative 2,3 and 6 | Bromadiolone 50ppm<br>Alternatives 4,5 | Diphacinone 50 ppm<br>Alternative 6 |
| $LD_{50}$ (mg/kg; range) | 0.26-0.56 [a] | 0.56-0.84 | 2.3 – 7.0 |
| Rat Weight (g)[b] | 150 | 150 | 150 |
| mg Active Ingredient | 0.039 - 0.084 | 0.084 – 0.13 | 0.35 – 1.05 |
| Amount of Bait (g) | 1.56 – 3.36 | 1.68 – 2.52 | 6.9 - 21 |
| Number of Pellets | 0.78 – 1.68 | 0.84 – 1.30 | 3.5 – 10.5 |
| Number of Feeding Days[c] | 0.16 – 0.34 | 0.17 – 0.25 | 0.69 – 2.1 |

a $LD_{50}$ for black rat (R. rattus) is 0.65-0.73. All $LD_{50}$ data is for Norway rat (Laboratory). Comparing laboratory rat data across the different rodenticides, bromadiolone is half as toxic as brodifacoum. If the $LD_{50}$ differences between brodifacoum and bromadiolone for the lab rat follow a similar pattern for the black rat, the $LD_{50}$ data presented may be too low. Conservatively, the feeding estimates should be considered an absolute minimum to one $LD_{50}$.

b from Erickson (1990)

c assumes approximately a 10g daily requirement of dry matter per day based on the allometric equation: Food Ingestion Rate (g/day) = $0.621(\text{Weight})^{0.564}$ . Assumes bait is 100% Dry matter and satisfies daily requirements.

that rats are required to feed on the bait over a period of days (estimated around 7 days) to cause death. This is due to the ability of rats to metabolize and excrete the chemical in a relatively short period of time negating the toxic effect of the initial dose. However, if the rats feed on the bait exclusively for a period of days, the toxic effect will take hold and cause death. Brodifacoum and bromadiolone are somewhat insensitive to metabolism, relative to diphacinone. These compounds can cause death after a “single feeding” if enough of the rodenticide is consumed. In other words, rats on the island would have to only consume a small amount of bait to cause death if brodifacoum or bromadiolone were used in sufficient concentrations (which would still be less amount of active ingredient than if a first generation compound were used). From an eradication standpoint it is necessary that every individual exposed to the rodenticide succumbs. Therefore, a bait, able to kill after ingestion a single mouthful would be most efficient for eradication purposes (Eason 1991 as cited in Taylor 1993).

Variation exists within every rat population to the susceptibility of the rodenticides. Of most interest in an eradication program are those individuals which require more and more bait to induce mortality, or show bait avoidance behavior. It is those individuals that may cause failure and form the founding population in the future, making it that much harder to remove rats from the island because of the inherited lower susceptibility. Diphacinone, with its multi-feeding requirement to induce mortality, increases the probability of rats surviving post application due to bait avoidance, inadequate bait consumption or other mechanisms. The use of brodifacoum is proposed to "clean up" those remaining individuals that were not lethally exposed to the diphacinone bait. However, under alternative 6, the repeated use of diphacinone bait would select for individuals that require more and more rodenticide to be killed or show higher bait avoidance behavior due to previous exposure to diphacinone. If rats that survive show bait avoidance behavior, they may avoid the brodifacoum bait when presented. Thus, there is lesser confidence in achieving eradication under alternative 6. Bromadiolone, (alternatives 4 and 5) would increase the probability of killing all target animals because of its greater toxicity and its "single-feeding" label. However, bromadiolone has been shown to be unable to control 100% of *Rattus rattus* after two day's of feeding on 50 ppm bait (Buckle 1994). After the presentation of equal concentration of brodifacoum and bromadiolone to a study population of black rats, only brodifacoum killed 100% of the rats after 1 day and 2 days of presentation. Bromadiolone was only effective in killing 47% and 90% after one and two days of feeding (Buckle 1994).

Only brodifacoum offers the highest probability of achieving the 100% kill of rats, thus, meeting the purpose and need of the Anacapa Island Restoration Project. Brodifacoum has been the most extensively used rodenticide in island restoration practices worldwide (Appendix C).

## *Composition of Bait and how it is Applied*

This section investigates how the composition of the bait and its application method would affect the outcome of the restoration project. The composition of the bait would be commercial manufactured baits, either in pellet or block form. The application technique, either bait stations and/or aerial broadcast, would differ in probability of eradication, primarily based on the movement of rats on the island. To successfully eradicate rats, bait must be delivered into each rat's territory across the island (Appendix C).

Each of the alternatives outlines the use of different rodenticides and/or methods of delivery. In each case, the aerial broadcast would utilize a commercially manufactured compressed grain pellet. Bait stations would be armed with commercial grade blocks of approximately 20 g or the 2 g compressed grain pellets. The baits would be formulated for high palatability and acceptance by rats and would be consumed readily by the target species.

### *Alternative 1: No Action Alternative*

Under the no action alternative, there would be no use of rodenticides in the Anacapa environment, except for the localized baiting in buildings on east island. With no rodenticide application, the rat population would not be controlled, and the numbers of rats on the island would fluctuate within the annual cycle. Efficacy would effectively be 0% on Middle and West Islands, and very small (>0%), on East Island where control would take place in the few buildings.

### *Alternatives 3 and 5: Aerial- Bait Station Combination*

The use of bait stations on top of the island as well as aerial broadcast of the rodenticides onto the cliffsides was developed to minimize the exposure of non-target species to the rodenticide through direct bait consumption. Although it minimizes the primary exposure risks to non-target species, may compromise the success of the eradication because some individuals possibly would not be exposed to the bait.

Habitat utilization by rats on Anacapa Island follows an annual cycle. Rats are most abundant along the shoreline during the late dry season, and in very low density on the slopes and top of the island (Erickson 1990; Howald et al. 1997; Collins 1979). General observations have suggested that during the wet season, the rat populations increase and subordinate individuals are pushed into marginal territories, such as up the slopes and on top of the island. As the dry season progresses and food availability on top declines, the abundance of rats on top declines. Rats have been found in very low density on top of the island during the late dry season, but not absent (Howald et al. 1997; ICEG 2000). With the use of bait stations, some rats may not enter the stations even though they are present in their territory. This neophobic behavior, common in rats (Greaves 1994), may prevent some individuals from gaining access to bait in the stations. Bait stations deployed only on top of the island may allow for rats to enter the rodenticide free cliffsides once the aerial application is complete. As most cliff/shore dwelling rats have died, the subordinate rats may move off the top of the island down to the shoreline into preferred habitat, where they would escape exposure to the rodenticide and meet no resistance from territorial rats. These individuals could form the founder population. To overcome this potential, stations would be left armed for over a year before any aerial broadcast activity. This could allow for neophobic rats to get used to the stations over time, enter, and consume the bait and die. Alternatively, if rats refuse to enter stations, they may continue their day to day activities and die naturally without exposure to the rodenticide. Their offspring, if any, would emerge from their dens with the armed stations present in their territory and may readily enter the stations and consume bait. Conversely, their offspring may have inherited the behavior of bait station avoidance and could escape exposure. There is no island rat eradication recorded that used a combination of broadcast and bait stations and thus, there is no precedent for this type of operation. Alternatives 3 and 5 offer the lowest probability of successfully eradicating rats.

### *Alternatives 2, 4 and 6: Aerial Broadcast*

The aerial broadcast of the rodenticide across the entire island as laid out in alternatives 2, 4 and 6 increases the probability that 100% of the rats would be exposed to the bait. Rats would encounter pellets during their nightly foraging excursions and neophobic behavior, such as to bait stations, would be minimized.

## *Local Factors*

#### *Warfarin resistance*

An attempt to control and/or eradicate rats from Anacapa Island was carried out over a number of years in the 1980s and early 1990s. Many control methods were attempted, including warfarin delivered from bait stations. The control of rats can be a strong selection agent, increasing the frequency of rats that cannot be killed via the control method used. Where populations of rats have been previously exposed to poison, some rats demonstrate bait avoidance behavior and others may be biochemically “resistant” to the anticoagulant used (Greaves 1994). It is unknown if the population of rats on Anacapa Island contain individuals that would demonstrate bait shyness or are resistant to warfarin. Thus, it is recommended to use an active ingredient that would be lethal to “warfarin-resistant” individuals and is able to provide a lethal dose in a “single-feeding” in case of bait shy individuals. Second-generation anticoagulants would kill warfarin-resistant rats and, if in sufficient concentration, would kill rats after a single feeding, thus, dramatically increasing the probability of successful eradication.

### Timing

Rat eradication programs are most likely to be successful if they take place during the annual population cycle when no reproduction is taking place and when rat numbers are declining. This insures that new-born rats would not emerge from the dens after all bait has been consumed, and that most rats would be food stressed and therefore more likely to consume bait. Based on the population fluctuations and breeding season of black rats on Anacapa Islands, October through January is the best period for eradication (Collins 1979, Erickson & Halvorson 1990). Each of the alternatives would be initiated during the low point in the annual cycle.

## Summary

This analysis has demonstrated that strictly from an efficacy standpoint, Alternative 2, the preferred and proposed action (the use of brodifacoum aerially and hand broadcast) would offer the highest probability of achieving eradication and meeting the purpose and need.

# Issue 2: Non-Target Impacts

## Introduction

Non-target species, are those species that may be negatively affected from the actions of the project, has been broken in to two components, the physical impacts and exposure to rodenticide residues.

Physical disturbance may occur from baiting activities, and crews walking around the island. Rodenticide exposure, for the purpose of this analysis, can occur through direct bait consumption (primary exposure) and secondarily (via carcasses containing rodenticide residues).

## Physical Impacts

### Introduction

This section will analyze the impacts from both baiting and crews walking around the island conducting research and monitoring on the project. The analysis is broken down by baiting technique within alternative - aerial or bait station. Within each category, the direct and indirect impact to each sub-issue will be analyzed.

### Alternative 1: No Action Alternative

The physical impacts of this alternative would be negligible. Physical impacts would be restricted to normal Park activities as well as intermittent Navy and Coast Guard aerial activity around the island.

Under this alternative, no baiting would take place and therefore, risk of rodenticide exposure would be restricted to non-target species in an and around buildings where rat control with rodenticides would take place.

Rats would continue to be a major perturbation in the Anacapa ecosystem, continuing to have detrimental impacts on small crevice nesting seabirds, the deer mouse, invertebrates, and plants.

The rats would continue to prevent the smaller pelagic seabirds, such as Xantus' murrelet and ashy-storm petrel, from nesting outside of the sea caves. Murrelets would continue to be restricted to nesting in areas inaccessible to rats, although abundant nesting habitat is found elsewhere. Murrelets utilize only 0.4% of available habitat on Anacapa Island compared with 30% on rat-free Santa Barbara Island (G. McChesney, unp. data.). Rats would continue to predate nesting seabirds and their eggs, further leading to declining population levels of the Xantus' murrelet. The declining population may lead towards protection under the Endangered Species Act.

The endemic mouse on Anacapa Island would continue to be at risk of extirpation. Rats have been implicated in the 20 year extirpation of deer mice from East Anacapa Island, rediscovered in 1997. Rats had likely preyed and outcompeted the mice which resulted in extirpation. The extirpation of mice from the islets could re-occur, and could have serious implications for birds of prey which rely on the mice as their primary prey base.

The intertidal zone would continue to be an important foraging area for rats. The invertebrates would continue to be impacted, especially the lined shore crab. The terrestrial invertebrates would continue to be an important part of the rat diet. The population of terrestrial mollusks on Anacapa Island, which are very rare, would unlikely recover.

The flora of Anacapa Island would continue to be detrimentally impacted. The rats would continue to be an important vector for dispersing seeds of iceplant, a highly invasive non-native species which "chokes out " native species. The island oaks and cherry trees on West Island would continue to have low regeneration which could result in complete failure of regeneration of the species. There is a possible severe economic impact to the National Park Service with trying to constantly restore native habitat due to rodent activities.

## *Effects Common to Alternatives 2, 3, 4, 5, and 6: Aerial Broadcast*

Under each of the alternatives, a helicopter would aerially spread a rodenticide from an underslung hopper. The helicopter would fly 25-50 m above ground at an airspeed of approximately 50 knots. Under each of the alternatives, bait would be aerially broadcast on the cliffsides and all of West Island would be treated. Alternatives 2, 4 and 6 propose broadcast of the top of Middle and East Islands as well. Alternatives 3 and 5 would use bait stations on top of the island and the impact associated with that will be covered in a separate section below. The total treated area varies between the alternatives; however, the flight operations may have a net impact to some species. To ensure even and adequate coverage of the island, a crew would circumnavigate the island by boat spreading bait by hand in key locations.

The project's efforts in eradication and subsequent potential impacts to non-target species and the environment would be monitored. Crews of varying sizes would regularly visit study sites and collect appropriate data.

### *Sub-issue 1 – Marine Mammals*

Direct - Resting California Sea Lions and Harbor Seals would likely be disturbed by the helicopter activity and boat traffic to hand broadcast bait. It is likely that these species would retreat from their resting areas to the ocean. The disturbance to this group is likely to be short, restricted to three passes of the helicopter. The seals and sea lions would likely return to the haulouts shortly after the disturbance. This type of activity is somewhat common with functions performed by boat traffic around the islands daily.

Monitoring activities by research crews would not take place in the vicinity of the haulouts and would not result in disturbance or other effects.

Indirect - The seals and sea lions would not be subject to any indirect effects as a result of disturbance. The disturbance would be of short duration, and there would be plenty of alternate haul out areas around the islands individuals could retreat to.

### *Sub-issue 2 - Invertebrates*

No impact to this group is expected from helicopter or any other physical activities.

Monitoring on study plots and traversing along trails would not have a significant impact on this group of animals.

### *Sub-issue 3 – Fishes*

Direct - No impact is anticipated other than minor disturbance from intermittent inflatable boat traffic. The extent of boat traffic at any one point along the shoreline would be very intermittent. This would result in only minor disturbance. The fish would return to normal activities soon after departure. Boat traffic around the Anacapa shoreline is common and frequent. The additional inflatable boat traffic would not be expected to increase disturbance outside regular Park traffic.

Indirect - No indirect impacts would be anticipated.

### *Sub-Issue 4 – Herpetofauna*

Direct - The impacts to the herpetofauna would be disturbance associated with foot traffic from researchers. The salamander would be dormant or deep within thick vegetation during the proposed application period and would be at low risk of disturbance. There would likely be disturbance to the Side-blotched and Alligator Lizards which would be active on most regions of the island at the time of baiting. The visiting public walking along trails regularly disturb sunning Side-blotched Lizards, that quickly return to their spots after the disturbance has passed.

Indirect - There would be no indirect impacts to this group.

### *Sub-Issue 5 – Seabirds*

#### *Pelagic Seabirds*

Direct - There would be no impact to the pelagic seabirds during the baiting operation, these species would be foraging offshore. During the breeding season, these species would be susceptible to disturbance from research crews walking around the island, causing flushing from nesting areas. Few, if any, pelagic seabirds would be expected to nest on top of the island due to predation pressure from rats.

Indirect - There would likely be no indirect effects from short duration disturbance. If disturbance was of long duration or chronic, there could be nest abandonment or susceptibility to predation. However, disturbance is expected to be of short duration, thus likely having no indirect effect.

#### *Roosting Seabirds*

Direct - The effect on the seabirds would be in the form of disturbance. Seabirds that roost on the island would likely be flushed as the helicopter approaches. The main species of concern is the endangered brown pelican. Boat activity along the shoreline to dispense bait would likely flush roosting seabirds. Disturbance to roosting pelicans by boat traffic around the island has been observed on Anacapa Island (B. Keitt, pers. comm.). Most pelicans return to the same roosting location 10-30 minutes after disturbance (B. Keitt, pers. comm.), or would likely roost elsewhere. Coast Guard and Navy helicopter activities occur periodically on and around East Anacapa Island with no detrimental impact to roosting Brown Pelicans (F. Gress, pers. comm.)

Monitoring activities of research crews may disturb roosting seabirds. However, study protocols have been designed such that only minimal activity would take place around known roosting areas, and therefore, disturbance would be minimal. Monitoring would occur during the breeding season but no monitoring would take place in the vicinity of the pelican colony on West Island. Monitoring would be conducted around breeding Western Gulls. Disturbance is the only direct effect expected; however, it would be of minor significance as gulls are routinely disturbed by visitors on East Island and nest successfully.

Indirect Effects - Disturbance to roosting seabirds would have a low probability of indirect effect. The disturbance from both aerial and hand-baiting would be short and there is plenty of alternative roosting areas available on the island.

Repeated or chronic disturbance would not be expected under any alternative.

### *Sub – Issue 6 - Landbirds*

Direct - The immediate effects on avian species of helicopter use above Anacapa Island and the bait drop would involve disturbance of roosting species. This immediate effect would be minimal as the normal response of the land birds would be to take cover in surrounding vegetation. The stress associated with this activity is unlikely to be greater than that caused by certain visitor activities on the island or by helicopter use associated with other Park operations made in the past or future. The helicopter would likely cause birds of prey to flush from roosting areas. Flushing of species is a common occurrence with visitors to East Island, and individuals usually return to their roost after 10 to 30 minutes. These effects are unlikely to exceed those incurred during normal Park operations.

Falling bait pellets would unlikely have a significant effect. The approaching helicopter would likely cause landbirds to either leave the area or move into areas that offer protection such as thick vegetation, which in turn would offer protection from falling pellets.

Indirect - During the baiting operation, indirect effects would not be expected and are insignificant. Nesting landbirds could be disturbed during research and monitoring. No chronic activity would be expected.

### *Sub - Issue 7 - Terrestrial Mammals*

Direct - No impact to the deer mouse is expected. The deer mouse is primarily nocturnal and would be in their burrows during the aerial application of the bait in the daylight hours. Minor disturbance to mice may occur while monitoring nocturnal species. However, this disturbance would be restricted to trail and building areas and would not have any long term consequences.

Indirect - No indirect effects are anticipated from helicopter activity or monitoring activities.

### *Sub - Issue 8 - Flora*

Direct – The Island Malacothrix is an annual species that would not be growing or in bloom during the application window. It would not be susceptible to the rodenticide and would not absorb any residues. It may be susceptible to trampling damage during the monitoring period after the bait has been applied and the growing season has started.

Indirect - Soil compaction from repeated foot traffic over the growing areas of the Island Malacothrix could result in increase water runoff, leading to increased erosion during the rainy season, resulting in degraded habitat impairing productivity of this species.

Mitigation – To mitigate against any damage to this species, NPS botanists will identify and mark known locations of the malacothrix. Personnel working on Middle Anacapa Island will be advised of the presence of the plant and will be briefed thoroughly on techniques to minimize trampling of the area surrounding malacothrix locations.

## *Effects Common To Alternatives 3 and 5: Bait Stations*

The use of bait stations on top of East and Middle Islands is common to both alternatives 3 and 5. In these alternatives, bait stations would be placed at equal distances on a grid pattern around the island. The stations would be checked daily until the activity (bait removal) ceases or declines precipitously. Then the stations would be checked monthly throughout the year until the following year when they would be re-armed and checked during the aerial broadcast operations.

***Sub-issue 1 – Marine Mammals***

No direct and indirect effects because bait stations are on top of island, well away from flushing distances to the haul-outs.

***Sub-issue 2 - Invertebrates***

No impact to this group is expected from placing and checking stations.

***Sub-issue 3 – Fishes***

No direct or indirect impacts, bait stations are in the terrestrial environment.

***Sub-Issue 4 – Herpetofauna***

Direct - There would likely be disturbance to those individuals that are along the trail network used to gain access to bait stations.

Indirect - There would be no indirect impacts to this group.

***Sub-Issue 5 – Seabirds***

*Pelagic Seabirds*

Direct - There would be no impact to the pelagic seabirds, these species would be foraging offshore during the initial baiting period. The monthly checks of the bait stations would likely overlap with the breeding season. If the pelagic birds are nesting on top of the island, crews moving between stations may disturb birds, and cause them to flush.

Indirect - The birds would likely return to their nests once the disturbance is passed.

*Roosting Seabirds*

Direct - There would be minor disturbance to nesting Western Gulls on Middle and East Anacapa Island during the bait station checks. The impact of the disturbance would be flushing from territories, however, this is believed not to have a great impact because gulls are routinely disturbed by visitors to East Anacapa Island with no detrimental impact.

Roosting Brown Pelicans would be flushed from roosting locations. The use of bait stations would require frequent checks and would result in frequent disturbances to pelicans.

Indirect Effects – Daily checks of bait stations would occur over the winter into the early spring when nesting by Western Gulls has been initiated. Regular station checks could potentially lead to nest abandonment or for opportunistic predation by other species as a result of disturbance.

The chronic disturbance to roosting pelicans could result in roost abandonment. Roost abandonment would be insignificant as there are alternative roosting areas around Anacapa Island such as on West Island which would not be disturbed from bait station use.

***Sub – Issue 6 - Landbirds***

Direct - Repeated disturbance to birds nesting or establishing nesting territories may cause nest or territory abandonment. However, it is believed that there would be no significant disturbance to any of the species to cause nest or territory abandonment. During the breeding season, the checks of the bait stations would be intermittent.

Indirect - There would be no indirect effects expected because of the low direct impacts.

***Sub - Issue 7 - Terrestrial Mammals***

Direct - No impacts to the deer mouse is expected. This species is nocturnal, all checks would be conducted during daylight hours. The mice would be in their burrows.

Indirect - No indirect effects are anticipated from repeated checking of bait stations.

***Sub - Issue 8 - Flora***

Direct – The Island Malacothrix is an annual species that would not be growing or in bloom during the application window. It may be susceptible to trampling damage during the monitoring period after the bait has been applied and the growing season has started.

Indirect - Soil compaction from repeated foot traffic over the growing areas of the Island Malacothrix could result in increase water runoff, leading to increased erosion during the rainy season, resulting in degraded habitat impairing productivity of this species.

*Mitigation*

To mitigate against any damage to this species, NPS botanists will identify and mark known locations of the malacothrix. Personnel working on Middle Anacapa Island will be advised of the presence of the plant and will be briefed thoroughly on techniques to minimize trampling of the area surrounding malacothrix locations.

# *Toxicological Impacts*

## *Introduction*

The main toxicological issue associated with the Anacapa Island Restoration Project is the potential impact to other wildlife species from rodenticide exposure. For the purpose of this analysis, incidental wildlife species potentially at risk of exposure to the rodenticide are defined as non-target species. To fully and effectively present the potential toxicological impacts to non-target species, this section is organized to give background into the biochemistry of the rodenticides, followed by a relative comparison of toxicological impacts by alternative. Within the relative comparison of toxicological impacts section, the potential direct (primary) and indirect (secondary) exposure to the rodenticides is analyzed by alternative. In the last section, the analysis would focus on the direct and indirect toxicological impacts presented by the respective sub-issue.

***Biochemistry***

The proposed action and alternatives have outlined the use of second generation and first generation anticoagulant rodenticides. The anticoagulants act by blocking the vitamin K oxidation-reduction cycle in the liver microsomes, preventing the production of activated clotting factors (Thijssen and Baars 1989). Death results not from the active ingredient itself, but the uncontrolled bleeding after tissue damage (Brown et al. 1988). For a non-target species to be at risk of hemorrhaging, it would have to consume a minimum amount of the anticoagulant. Before any symptoms of anticoagulant poisoning are measured, a threshold level (concentration in the liver) must be reached. Symptoms include, but are not limited to, increased time to clotting (prothrombin times (PT) ) leading to hemorrhaging. A minimum amount of active ingredient needs to be consumed, absorbed and bound in the liver, and significantly decrease the production of active clotting factors resulting in an increased prothrombin time, before an individual is considered at risk of hemorrhaging. Thus, organisms are able to tolerate sub-lethal levels of anticoagulants without displaying any symptoms of poisoning. Above that threshold, the risk of hemorrhaging is high and measurable (eg. increased clotting time). Once at risk of hemorrhaging, activity is required to induce hemorrhaging and subsequently mortality (spontaneous hemorrhaging is possible, i.e., although low activity, hemorrhaging still occurs). Without the presence of enough anticoagulant the induction of hemorrhaging, and subsequently mortality would not occur. Thus, all animals are able to tolerate some level of anticoagulant rodenticide exposure without risk of hemorrhaging. The level of risk is determined by the toxicity of the chemical and that individual's exposure. This analysis will focus on the potential primary and secondary poisoning risks to the wildlife resources.

The relative risk of non-target species poisoning on Anacapa Island is determined by a number of variables including the toxicity and exposure to the rodenticide. Exposure is determined by the availability of the active ingredient in both space and time. Primary poisoning occurs when species feed directly on the bait. Secondary poisoning occurs when animals feed on primarily poisoned organisms that have rodenticide residues in their tissue. The potential of tertiary and quaternary poisoning exists (eg. birds or mice that consume carrion insects, containing residue of active ingredient after digesting a primarily poisoned mouse, would be tertiarily poisoned) but has not been thoroughly documented. For the purpose of this analysis, the risks of primary and secondary exposure to the rodenticides will be investigated as per Record and Marsh (1988). Primary exposure to the rodenticides is determined in part by:

- Toxicological properties of the rodenticide
- Bait composition and delivery into the ecosystem
- Non-target species behavior and foraging strategy
- Local environmental factors;

Secondary exposure to the rodenticides is driven by any one species primary exposure to the rodenticides. In addition to the above factors, the behavior and location of death of the target species will influence secondary poisoning.

## *Relative Comparison of Toxicological Impacts by Alternative*

This section will compare the potential toxicological impacts by alternative. Under the features common to alternatives 2 – 6, each section will evaluate the variables (toxicology, bait composition, behavior of species and local factors) that contribute to risks of non-target species exposure to the rodenticide. This section will follow with a breakdown of toxicological impacts by sub-issue. Where possible, an acute risk of exposure to the rodenticides was evaluated for each sub-issue and rodenticide.

## *Alternative 1 – No Action*

Under this alternative, there would be no application of rodenticides, therefore there would be no toxicological impacts.

## *Features Common to Alternatives 2, 3, 4, 5 and 6*

### *Primary Exposure*

#### *Toxicology*

The rodenticides are vertebrate toxicants. All the rodenticides presented in the alternatives are toxic to all the vertebrates, provided they are exposed to the rodenticide in sufficient quantities. The toxicity to both the target and non-target species will determine the relative primary and secondary exposure risks. The risks of exposure to the anticoagulants is determined by how well the non-target species is able to metabolize and excrete the compound, which is

Table 8. Primary exposure index for each alternative

| | Alternative | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Ranking (Low to Highest) | 1 | 4 | 2 | 6 | 5 | 3 |

a function of its acute toxicity. Further analysis will be presented by sub-issue (see below).

### *Bait Composition and Delivery into the Ecosystem*

The bait composition and method of delivery into the ecosystem would influence how and if species are primarily exposed. The bait formulation (inert products, size of pellet) and method of dispersal into the Anacapa ecosystem would determine the relative primary exposure risks. For example, granivorous species would be more interested in rodent bait composed of a compressed grain pellet vs a high protein “meat” bait. The insectivorous, or carnivorous, species may “avoid” a bait that is composed of compressed grain. Similarly, size of the bait itself plays an important role in determining if a species may be exposed to the bait itself. The smaller species may not be physically able to consume the bait due to its size, in contrast, the larger species may not be interested in small pelleted bait if available. Thus, some species are “ protected” from feeding on the bait because of its size. Under all alternatives, the bait would consist of a compressed grain pellet and could be attractive to most granivorous/omnivorous species capable of ingesting that size pellet. Alternatives 3 and 5 would see the use of a block that is larger than the pellets and would limit further species from consuming the bait.

How bait is delivered into the Anacapa Island ecosystem would determine the scale of potential rodenticide exposure. The alternatives outline the use of aerial/hand broadcast and bait stations for delivery of the rodenticide onto Anacapa Island. The aerial broadcast of the rodenticides has been demonstrated to represent a risk of non-target exposures to the rodenticides (Edward et al. 1988).

A risk index (Edward et al. 1988) to provide a measure of primary exposure risk when evaluating rodenticides was utilized to qualify the relative primary exposure risks among the alternatives. The risk index takes into account bait concealment ( C - scored 1 to 3, high to low), quantity of bait placed (Q), and numbers of animals present (N). Using these factors, the equation:

$$\sqrt[3]{(C \times Q \times N)}$$

can be utilized to evaluate the relative primary exposure risks. For the purpose of this analysis, the primary poisoning risk index was calculated for each alternative using: 3 for low concealment (aerial) 1 for high concealment (bait stations), bait quantity per hectare applied, and assumes that only one non-target animal is present. For the alternatives with both bait stations and aerial application (alternatives 3 and 5), and alternative 6 (two different rodenticides), the risk index was calculated for each application technique and/or rodenticide, and averaged. The scores were ranked from lowest primary exposure risk to highest for comparative purposes (Table 8).

The risk of primary exposure is highest under alternative 4 and lowest under alternative 3. The highest risks of primary exposure occurs when the rodenticide is broadcast, and lowest when presented in bait stations. Presenting bait in tamper proof bait stations limits access of the bait to rats and species smaller than rats (such as deer mice and invertebrates). The use of bait stations would lower the scale of rodenticide exposure, but it would not reduce the risk of exposure to zero. Although the relative exposure risks between the alternatives vary, it would be impossible to preclude the possibility of exposure. The Risk Index is useful as a tool to evaluate the primary exposure risks, alone it does not provide an adequate measure of the relative risks.

### *Behavior of Non-Target Species*

The behavior of the non-target species and their associated foraging strategy is an important determinant in risk evaluation. The hazard of the rodenticide is a function of toxicity and exposure (Record and Marsh 1988). Although the toxicity of a rodenticide is high in some cases, the non-target species needs to be exposed to the rodenticide to be considered at risk. Exposure may not occur if the species is not present during the baiting operation, or does not feed on the bait or a primarily exposed organism, thus avoiding both primary and/or secondary exposure.

### *Local Environmental Factors*

Exposure to the rodenticide, primary or secondary, is determined by the availability of the rodenticide in space and time. The conditions of the local environment will influence the availability of the rodenticide by enhancing the degradation of any residual bait (or not). The application rate was determined by consumption rates of rats and mice over a 4 day period. The majority of the bait will be consumed by rats and mice, leaving few pellets in the environment. The combination of rainfall, fog and invertebrates will degrade the remaining bait pellets. The application will take place prior to the rainy season such that any remaining bait will absorb moisture and break up. The presence of moisture would encourage mold and microbial degradation of the rodenticide to its base components of water and carbon dioxide. Bait will not likely be present on Anacapa by the end of the rainy season.

Similarly, the timing of the operation will influence the scale of potential primary and secondary exposure risks. For example, migratory species may not be present during the aerial application window and therefore would not be exposed. Conversely, the use of bait stations over time would potentially put those species at higher risk.

### *Consequence of Primary Exposure*

Many variables must be taken into consideration when evaluating the primary exposure to the rodenticides. The consequence of primary exposure to the rodenticides may be an anticoagulated state leading to hemorrhaging and mortality. To characterize the consequence of primary exposure to the rodenticides, the toxicology data and exposure data (based on allometric equations (EPA 1993) were used to model the number of $LD_{50}$s individuals would be exposed to if they fed exclusively on the rodenticide bait for one day.

Risk quotients (RQs) were calculated by dividing the exposure estimates with ecotoxicity values:

RQ= Exposure/Toxicity

For the purpose of this discussion, an estimate of the primary poisoning risk to the birds and mice were estimated by calculating the number of $LD_{50}$s/day a bird would likely be exposed to if it fed exclusively on the bait, using the following formula:

$LD_{50}$s/day = mg rodenticide consumed/day ÷ [$LD_{50}$ x weight (kg)]

Where mg rodenticide consumed/day = amount of bait eaten x % active ingredient in the bait. Allometric equations were used to estimate amount of bait consumed daily (EPA 1993). If no $LD_{50}$ data existed for that species, the $LD_{50}$ from the species in closest taxonomic relationship was used consistently for each rodenticide (eg. Laboratory rat $LD_{50}$ data used for brodifacoum, bromadiolone and Diphacinone). However, caution must be used when interpreting this data because phylogenetic relationships cannot be used to predict sensitivity to the rodenticides (Hill 1994; Mineau, 1991). To more precisely present the relative risks of poisoning to non-target bird species, the LD50 data was statistically "corrected" following Mineau et al. (2000).

Table 9. Properties of the rodenticides affecting their potential for secondary poisoning.

| | Active Ingredient (Rodenticide) | | |
|---|---|---|---|
| | Brodifacoum [a] Alternative 2, 3 and 6 | Bromadiolone Alternative 4, 5 | Diphacinone Alternative 6 |
| Sensitivity to Metabolism | Low | Low | High |
| Tissue Retention | High | High | Low |
| Biological Half-Life | Long | Long | Short |
| Estimated time | 150-200 days (RED 1998) | 318 days (RED 1998). | 15-20 days (WHO 1995) |

For regulatory purposes, the EPA evaluates the Risk Quotients and compares them to the Office of Pesticide Programs Level of Concerns (LOCs). LOCs are evaluated as: Acute High Risk (LOC >0.5), Acute Restricted Use (LOC >0.2), and Acute Endangered Species (LOC >0.1). It is on this evaluation that the EPA restricts certain pesticides from certain use patterns or availability to public or professional pest control uses. For the purposes of this discussion, any rodenticide with a RQ >0.5 is presumed to put that group of species at risk of lethal poisoning.

## Secondary Exposure

### Toxicology

Brodifacoum and bromadiolone are second generation anticoagulants while diphacinone is a first generation anticoagulant. In general, the difference between the two categories is the toxicity and the sensitivity to metabolism which is reflective in the toxicity. Upon ingestion and absorption, the anticoagulants bind to a "warfarin binding" protein in the liver microsomes where they act to prevent the production of active clotting factors. The first and second generation anticoagulants both bind at this site and the difference between the chemicals is their binding affinity at this site. Brodifacoum has a greater affinity than bromadiolone and both have a much higher affinity than diphacinone. Diagrammatically:

Brodifacoum>Bromadiolone>>>>Diphacinone.

This binding affinity may be the reason that the second generation anticoagulants are significantly more toxic. In general, the stronger the binding affinity, the higher the toxicity. The binding affinity is also related to the ability of the organism to metabolize and excrete the compound. The stronger the binding affinity, the greater the resistance to metabolism once bound. Thus, the ability to metabolize

Diphacinone>>>>Bromadiolone>Brodifacoum.

The implications of the sensitivity of metabolism is that relative risks of secondary poisoning vary between the rodenticides. For example, mortality was found in barn owls fed brodifacoum (5/6) and bromadiolone (1/6) dosed rats but no mortality was detected in barn owls (0/2) fed diphacinone dosed rats (Mendenhall

Table 10. Potential for accumulation of the rodenticides for the different sub-issues.

| Sub-Issue | Active Ingredient (Rodenticide) | | |
|---|---|---|---|
| | **Brodifacoum Alternative 2, 3 and 6** | **Bromadiolone Alternative 4, 5** | **Diphacinone Alternative 6** |
| Marine Mammals | High | High | Low |
| Invertebrates | Low | Low | Low |
| Fishes[a] | High | High | Low |
| Herpetofauna[a] | High | High | Low |
| Birds | High | High | Low |
| Mammals | High | High | Low |

a No literature data available, however, estimated to follow similar pattern as for mammals and birds.

and Pank 1980). This is suggestive also of the potential secondary poisoning impact of single versus multiple exposures to the rodenticides. Brodifacoum would have a higher potential for secondary exposure impact after a single exposure, while diphacinone may require multiple exposures to illicit the toxic effect. With brodifacoum and bromadiolone, because death is delayed between 3-10 days (for rodents and birds), they would continue to feed on the bait long after a lethal dose has been ingested, allowing for accumulation of the rodenticide in the carcass and liver. With diphacinone, the high rate of excretion and metabolism does not allow for significant levels of residues to accumulate in the carcass, although residues would be present and would present a secondary poisoning hazard. Diphacinone bait requires rats to feed on the bait over a period of up to 7days to illicit the toxic response. During that period, the rats are rapidly metabolizing the compound. Because ingestion is believed to be faster than metabolism, rats will eventually reach the threshold and a toxic response is measurable, potentially negating the secondary poisoning "protection". In comparison, brodifacoum and bromadiolone are "single-feeding" anticoagulants and are capable of illiciting a toxic response to the target species after a single feed. Table 9 summarizes the factors affecting the secondary toxicity of the rodenticides in the alternatives.

The low sensitivity to metabolism, high retention of residues in tissue and long biological half life of the second generation anticoagulants present a secondary exposure hazard to species preying on primarily exposed organisms. Godfrey (1985) demonstrated that most of brodifacoum administered to rats that survived the dosing was retained up to 10 days after administration. Sheep dosed with brodifacoum at 2 mg/kg showed liver concentrations of 2 mg/kg four months later (Rammell et al. 1984). However, the biological half life must be qualified. For a sub-lethally exposed organism, the decline of the anticoagulants have been demonstrated to be biphasic – a rapid phase (in which the majority of toxicant is excreted) followed by a very slow phase (lower toxicant loading in the tissue) (RED 1998). Diphacinone, with its high sensitivity to metabolism, low tissue retention and short biological half-life, would not accumulate in predators as brodifacoum or bromadiolone. In other words, diphacinone offers greater secondary exposure protection than do either bromadiolone and brodifacoum. Thus, the second generation anticoagulants present a short term and long term non-target secondary poisoning potential and have the potential to present a poisoning hazard to non-target species especially through cumulative exposures.

The potential for accumulation and retention of the rodenticides for each of the species in the sub-issues is outlined in Table 10. The invertebrates are expected to accumulate minimal if any residue (Pain et al. 2000, Howald 1997). The residues available in the invertebrates are believed to be restricted to the presence of the chemical in the gut of the organism. Thus, digestion time of the bait is the critical period as a secondary exposure hazard.

### *Composition of Bait and how it is Applied*

The above analysis demonstrates that the anticoagulant rodenticides represent a potential secondary poisoning risk to non-target species. However, the levels of residues found within carcasses can be mitigated through alteration of concentration of active ingredient and its application technique. From a secondary poisoning perspective, by decreasing the concentration of active ingredient applied, the residue body burden found in target species carcasses is lessened. For example, Kaukeinen (1982), fed voles 10 ppm and 50 ppm brodifacoum bait. The brodifacoum concentrations were 4-10 fold more in those voles that fed on the 50 ppm brodifacoum bait.

Table 11. The relative secondary poisoning potential over time.

| | Alternative | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Temporal | NA | Short | Long | Short | Long | Short |

Thus, the concentration of the active ingredient has a secondary poisoning consequence.

The delivery of the bait onto Anacapa Island would occur by one of two methods: aerial broadcast and/or in combination with bait stations. Eradication of rats using the bait station approach would be a saturation baiting strategy where an "unlimited" supply of bait is offered until activity ceases or slows, then the frequency of checking and re-arming of bait stations is reduced. This allows for the possibility of "overkill" where rats are able to consume as much bait as they desire. Recently, Howald et al. (2000) evaluated the brodifacoum residue levels within Norway rat carcasses after an eradication effort from a large seabird colony using bait stations. The residue concentration levels within the carcass were partitioned equally in the liver (site of activity) and gastro-intestinal tract (primarily from unassimilated bait). Unassimilated bait found in the gut of rats found dead above ground, represented 30-50% of the total brodifacoum residue load, and reflected the saturation baiting strategy employed. The aerial application of the rodenticide may potentially limit the consumption of bait by rats with less chance of overkill and thus limit the residue loading in any one carcass (Record and Marsh 1988). The levels of the rodenticides that may be found in rats and mice cannot be readily predicted for each of the alternatives.

On Anacapa, rats may consume all the bait before mice have access to it, versus in a bait station where bait would be available in stations for mice long after rats have been eradicated. The presence of bait in stations in the long term would present a long term secondary poisoning potential, possibly outweighing the short term secondary poisoning potential (Table 11). In other words, the window of secondary poisoning from toxic rats and mice would be shorter with a single aerial broadcast, and longer with bait stations. For a successful eradication using bait stations, stations must be armed for well over a year, perhaps two (Kaiser et al. 1997, D. Veitch, pers. comm., R. Taylor, pers.comm.). Once rats have been eradicated, and mice begin to use stations and die, other mice would fill those territories, enter the stations, and consume bait. On Anacapa, the secondary poisoning potential from bait station delivery is determined by the length of time stations are left armed.

### *Behavior of Target Species on Intoxication and at Death*

The risk of secondary poisoning to predators/scavengers of rats and mice is limited by the availability of these prey in space and time. For the aerial predators on Anacapa, their search image is for live prey and thus risk of poisoning is during the latent period (after rats and mice have consumed the bait, but have not yet died) (estimated at 2 weeks). Anticoagulated rats demonstrate altered behavior which potentially makes them more susceptible to predation and scavenging. For example, Norway rats exposed to a lethal dose of brodifacoum spent significantly more time in open areas, sitting motionless or staggering about (Cox and Smith 1992, Gemmeke 1990). Most Norway rats radio-tagged in the field before baiting died underground in their burrows (87 – 100%) (Howald 1997, Taylor 1993). However, laboratory studies have demonstrated up to 50% die in the open (Cox and Smith 1992; Gemmeke 1990). Thus, anticoagulant poisoned rats and mice would be available to both diurnal and nocturnal predators and scavengers. On Anacapa, islet wide treatment would yield numerous dying rats and mice displaying erratic behavior and likely would be a significant prey base because of the ease of catching them. Optimal foraging theory indicates that an individual would use an area for foraging that would provide the greatest yield. Similarly, a number of rats and mice would die above ground and available for diurnal scavengers.

### *Local Environmental Factors*

The above analysis has demonstrated a risk of secondary exposure to the rodenticides, however, it does not consider the local conditions at the time of the application window. The late fall period corresponds to the late dry season, which is a time when conditions for most species can be difficult. Both the rat and mouse population would be at the lowest point in their annual cycle which would limit the numbers of poisoned rats and mice available to avian hunters and scavengers on the island. The onset of the rainy season soon after the bait has been applied will degrade the bait thus limiting the potential primary and secondary exposure.

## *Toxicological Impacts by Sub-Issue*

The analysis is broken down into the sub-issues, and within each sub-issue, broken down into primary and secondary exposure. The consequence of rodenticide exposure for each sub-issue, where possible, was calculated and is representative of a "worst-case" scenario. Where the Level of Concerns (LOC) exceed 0.5, suggested mitigation measures are presented.

### *Sub-Issue 1: Marine Mammals*

### *Primary Exposure (Direct)*

The risk of primary exposure to the pinnipeds is the same across all alternatives because of the aerial broadcast of the rodenticides onto the cliffsides. Alternative 6 is a higher risk for exposure because of the multiple treatments with both diphacinone and brodifacoum.

Toxicology - No data exists on the toxicity of the rodenticides to marine mammals. If consumed in sufficient quantities, the rodenticides are likely toxic to the seals and sea, impairing hemostasis as in the other vertebrates.

Bait Composition and Delivery - The aerial application of the rodenticides onto the cliffsides and shoreline of the islands present a risk that bait may drift into the ocean or land on the beach areas where marine mammals feed and haul out. Therefore, this group is at risk of primary exposure if they were to be attracted to the bait.

Behavior and Foraging Strategy - The pinnipeds feed exclusively in the marine environment, and only haul out to rest and breed.

The diet of the California Sea Lions and Harbor Seals is primarily composed of fish and

Figure 11. Risk Quotients for Harbor Seals

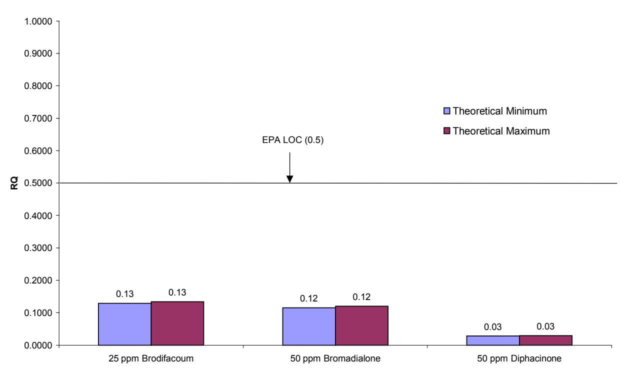



Table 12. The 48 hour $LC_{50}/EC_{50}$ (ppm) for freshwater invertebrates (from RED 1998).

| Species | Active Ingredient | | |
|---|---|---|---|
| | Brodifacoum | Bromadiolone | Diphacinone |
| Water Flea (*Daphnia magna*) | 0.98 | 0.24-2 | 1.8 |

other animal species, however, it is unknown if they would be interested in bait pellets falling through the water column if they were to drift into the marine environment. The bait is a grain based pellet, that would unlikely be attractive to the seals and sea lions. The primary exposure of the seals and sea lions to bait while hauled out on shore is believed to be very low. The seals and sea lions would be utilizing the haul-outs around Anacapa Island during the proposed period of baiting.

Rodenticide Exposure Risk - The sea lions and seals are at low risk of primary exposure because of their foraging strategy. Calculating their risk quotient assuming a "worst case scenario" where they would feed exclusively on the pellets revealed that their exposure falls below the EPA LOC of 0.5 for all rodenticides (Figure 11).

### *Secondary Exposure (Indirect)*

The diet of the California Sea Lions and Harbor Seals is primarily composed of fish and other animal species. Sea lions and seals are abundant around Anacapa Island during the proposed application window. If fish, predominantly sheephead, were to be primarily exposed to the rodenticide, the seals and/or sea lions may feed on the fish and be secondarily exposed to the rodenticide. This scenario is believed to be an extremely low probability because of the low probability of fish primary exposure – see above.

### *Sub-Issue 2 – Invertebrates*

#### *Primary Exposure (Direct)*

Toxicology - Limited data exists on the acute toxicity of the rodenticides to the invertebrates. The EPA released data outlining the acute toxicity of the rodenticides to the water flea, a freshwater invertebrate (Table 12). No other invertebrate toxicology data is available.

The anticoagulant rodenticides are not known to affect the terrestrial and intertidal invertebrates because of their different blood clotting systems (Shirer 1992). Extensive field and lab trials have shown that beetles (Morgan et al. 1996; Eason and Spurr 1995; Stejskal et al. 1994; Tershy et al. 1992), cockroaches (Godfrey 1985), wetas (Morgan et al. 1996), land crabs (Pain et al. 2000; D. Veitch pers. comm.), snails, slugs, orthopterans, millipedes (Howald 1997), and ants (Godfrey 1985; Tershy unpubl. data) are attracted to rodent baits and can survive on a diet of 20-50 ppm brodifacoum.

Bait Composition, Delivery and Behavior - This sub-issue combines both the marine and terrestrial invertebrates. The terrestrial invertebrates would play a significant role in the removal of residual bait that is not consumed by rats and mice. A wide range of invertebrate species would consume bait and may transport the rodenticide into the ecosystem (see Secondary Poisoning). Limited studies on Anacapa Island in 1999 showed that sowbugs are attracted to placebo bait (ICEG 2000). The invertebrates on Anacapa Island would play a significant role in removal of residual bait that is not consumed by rats and mice.

There is a risk that some bait may enter into the intertidal zone and ocean around the Anacapa Island. If bait were to enter, the marine fauna would likely be a significant factor in consuming any bait pellets. There would likely be no direct impacts to individual species as their blood clotting mechanisms are comparable to the terrestrial species (Shirer 1992).

The consequence of rodenticide ingestion appears to be insignificant to the invertebrates. However, the consumption of the bait by invertebrates may have significant consequences for species that prey on those species, potentially moving the rodenticide into the ecosystem.

No RQs were calculated because of lack of acute toxicity data and the apparent low susceptibility to the anticoagulant rodenticides.

#### *Secondary Exposure (Indirect)*

The invertebrates would play a significant role in the removal of carcasses containing residues of the rodenticides, thus would be secondarily exposed. The invertebrates would ingest the rodenticide, however, they would not carry significant levels of residues outside the resident time in the gut of the organism (Pain et al. 2000; Morgan et al. 1996). They would present a risk of movement of the rodenticide into the ecosystem.

### *Sub-Issue 3 – Fishes*

#### *Primary Exposure (Direct)*

Toxicology - No data is available on the toxicity of the rodenticides to marine fishes, however, data is available for freshwater species (Table 13).

Bait Composition, Delivery and Behavior - The drift of bait pellets into the marine environment from aerial broadcast is possible. The fish in the nearshore waters off of Anacapa Island are at risk of primary exposure through consumption of bait pellets that may fall through the water column. A small study was initiated in 1999 to identify those fish species that may consume bait (Table 14; ICEG 2000). Placebo baits were hand broadcast in small areas, the species present tallied along with their reaction

Table 13. The 96 hour $LC_{50}$ (ppm) for freshwater fishes (from RED 1998).

| Species | Active Ingredient | | |
|---|---|---|---|
| | Brodifacoum | Bromadiolone | Diphacinone |
| Rainbow Trout | 0.015 | 0.24 | 2.6 |
| Bluegill Sunfish | 0.025 | 3.0 | 7.5 |

to the bait pellets. The majority of the pellets that were falling through the water column illicited no response from marine fishes (62%). However, baits falling through the water column illicited an "inspection" response 20% of the time (inspection defined as approaching or following the pellet and/or "kissing" the pellet). Only sheephead was noted to actually take in and break up the pellet, but did not apparently consume the bait. Based on these results, sheephead is the only species to be considered at primary exposure risk if bait enters the marine environment. However, it is recognized that other species, or larger individuals of the species could be interested in bait pellets. Fish may also be at risk of exposure through the absorption of rodenticide residue across their gills if a high enough concentration is found within the water column. All the rodenticides in the alternatives are slightly to highly lipophilic and would therefore not be found in significant concentration in the water column. Any bait falling into the ocean would rapidly absorb moisture and begin to breakdown. Studies with placebo baits has shown that a compressed pellet lasts up to a "few hours" in calm conditions on the ocean floor (B. Keitt, pers.comm.). The incessant wave action and persistent swells on Anacapa Island would expedite the degradation process. On breakup of the bait pellets, the rodenticides, are not water soluble and would not readily stay in the water column, rather, begin to bind to available organic matter – such as marine animals and in the benthic layer. Therefore, the probability of a high enough concentration of rodenticide to enter into the sea and be of high enough concentration to be absorbed across the gills or skin of fish is low.

### *Secondary Exposure (Indirect)*

Predatory fish may consume any primary exposed fish and/or other prey and are secondarily exposed to the rodenticide. However, this event is not likely to be extensive and would not likely adversely affect any local populations.

## *Sub-Issue 4 – Herpetofauna*

### *Primary Exposure (Direct)*

Toxicology - No $LD_{50}$ data exists for the herpetofauna, however, studies have demonstrated equivocal results. In New Zealand, skinks found dead after an application of brodifacoum, tested positive for brodifacoum and showed symptoms of anticoagulant poisoning (see Eason 1995). This is in contrast to Tershy (pers. comm.) in which lizards were force fed 50 ppm brodifacoum bait. After two weeks, the lizards showed no symptoms of poisoning. No lab data is available to evaluate potential primary exposure.

Bait Composition, Delivery and Behavior - The three species of herps on Anacapa Island are primarily insectivorous and are at a low risk of primary exposure to the rodenticide. However, during an eradication campaign in New Zealand, Telfair's Skinks (*Leiolopisma telfairii*) reportedly consumed rain softened bait and succumbed to brodifacoum (Merton 1987 in Eason and Spurr 1995). The most significant pathway for rodenticide exposure is likely secondarily via their invertebrate prey base.

Table 14. Attraction of marine fishes to placebo baits, Anacapa Island, Spring 2000

| Common Name [a] | Species Name | Event | | | | | Grand Total [b] |
|---|---|---|---|---|---|---|---|
| | | No action | Inspected Bait | Touched Bait | Chewed Bait | Consumed Bait | |
| Blacksmith (391) | *Chromis punctipinnis* | 22% | 0% | 0% | 0% | 0% | 22% (11) |
| Garibaldi (19) | *Hypsypops rubicundus* | 6% | 6% | 6% | 0% | 0% | 18% (9) |
| Kelp bass (11) | *Paralabrax clathratus* | 6% | 2% | 2% | 0% | 0% | 10% (5) |
| Opaleye (100) | *Girella nigricans* | 16% | 4% | 4% | 0% | 0% | 24% (12) |
| Senorita (7) | *Oxyjulis californica* | 2% | 2% | 2% | 0% | 0% | 6% (3) |
| Sheephead (7) | *Pimelometopon pulchrum* | 6% | 0% | 2% | 2% | 0% | 10% (5) |
| Unidentified (14) | *Unidentified* | 2% | 2% | 2% | 0% | 0% | 6% (3) |
| Zebra perch (1) | *Hermosilla azurea* | 0% | 0% | 2% | 0% | 0% | 2% (1) |
| None (1) | *none* | 2% | 0% | 0% | 0% | 0% | 2% (1) |
| Grand Total | | 62% (31) | 16% (8) | 20% (10) | 2% (1) | 0% (0) | 100% (50) |

a Total number of individuals of a species during study in brackets.
b Number of events in brackets.

If the bait would be attractive to any of the lizards or salamander, the aerial broadcast of the rodenticide would increase the probability that greater numbers would be exposed. The use of bait stations on top of the island would spatially exclude most individuals from exposure, limiting exposure only to those individuals that have a bait station within their territory. If an individual was poisoned, that territory would become vacant and could be filled with another individual. That individual would then be at high risk of primary exposure. With an aerial broadcast laid out in the alternatives, the scale of impact would be a short window in time since the bait would be removed from the environment. Bait stations would have the potential for long term exposure to individuals.

No RQs were calculated due to lack of acute toxicity data.

### *Secondary Exposure (Indirect)*

The lizards and salamander are at risk of secondary exposure through consumption of primarily exposed invertebrates. It is unknown if the diet of the herpetofauna is similar or contains species that would degrade residual bait in the Anacapa environment.

### *Sub-Issue 5 and 6 – Seabirds and Landbirds*

### *Primary Exposure (Direct)*

Toxicology - Toxicity data exists for both groups of birds (seabirds and landbirds) (Table 15). Brodifacoum is the most toxic rodenticide to birds.

Bait Composition, Delivery and Behavior - *(Pelagic Seabirds)* The pelagic seabirds are considered to be at low risk of primary poisoning because of their foraging strategy which is almost exclusively offshore. They are almost exclusively carnivorous, preferring live prey. If during the aerial operations, bait was to fall into the water, and a pelagic seabird was in the vicinity, it may mistake a pellet for an injured fish and perhaps pursue and consume.

Most of the pelagic seabirds winter offshore from Anacapa Island and are at a very low risk of exposure.

(*Roosting Seabirds)* - The roosting seabirds, those that utilize Anacapa Island for roosting and tend to primarily feed offshore, are at greater risk of exposure to the rodenticide than pelagic seabirds. Recent studies documented Western Gulls exploring piles of placebo bait deliberately placed near roost sites (ICEG 2000). Similarly, placebo baits that were deliberately hand broadcast into the marine environment caught the attention of Western Gulls which subsequently investigated the bait. The attraction of gulls to the bait falling into the water drew more gulls into the area. However, the bait pellets fell through the water column quickly and no gulls were observed to successfully "fish" out any pellets.

The timing of the operation is late fall and early winter when gull numbers are at their lowest.

*Brown Pelicans*

There would be no direct effect of the rodenticide bait on the pelicans since they are fish eaters. There is no likelihood that they would ingest any bait directly, or secondarily from contaminated prey. The bait would be in a pellet form and is not expected to adhere to bird feet or feathers, therefore, it is unlikely that pelicans will inadvertently ingest the pellets during preening activities. Pelicans are not scavengers and will not eat dead and poisoned rodents. (It is expected that most (87-100%) of rodents will die underground after consuming the bait.) Pelican prey species are schooling fish such as anchovies and sardines, species which would not come into contact with the bait.

(*Landbirds)* - As a conservative estimate of primary exposure risks, the granivorous and omnivorous species are presumed to be at a primary exposure risk during the operations. Over 47% of the landbirds are either granivorous or omnivorous and may be subject to primary exposure risks on Anacapa Island (Table 16).

However, this is based upon year round occurrence of these species on the islands. During the proposed application period, many of the landbird species would have moved off the islands to their wintering grounds. On Anacapa Island, this reduces the number of species at risk from 59 granivorous/omnivorous species to 26. Further, recent surveys in November/December 1999 on Anacapa Island detected only 14 species, including carnivorous and insectivorous birds (ICEG 2000). The most abundant species were the House Finch, Bewick's Wren and Says Phoebe.

The interest in the bait by non-target species was investigated in the Fall of 1999 as part of the pre-eradication research. Placebo bait pellets were placed in exposed locations around Anacapa Island and observed from a distance. After 62 hours of observation time, only one pile was investigated by a Western Gull, which apparently did not ingest any of the pellets (ICEG 2000). However, during spring trials, placebo baits were investigated by Western Gulls and at least one was noted to consume pellets. No landbird species were noted around the pellets during the observation period. This data suggests that the relative risk of primary exposure to the landbirds would be lower than suggested by the above table.

Table 15. Acute Oral and Dietary Toxicity of Rodenticides to Birds ($LD_{50}$ mg/kg) (A dash indicates that no data is available) (RED 1998).

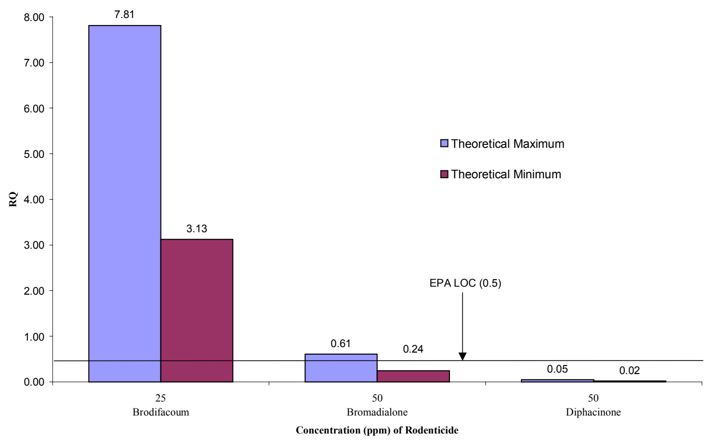
| Species | Active Ingredient (Rodenticide) | | | | | |
|---|---|---|---|---|---|---|
| | **Brodifacoum[a] Alternative 2, 3 and 6** | | **Bromadiolone Alternative 4 and 5** | | **Diphacinone Alternative 6** | |
| | **$LD_{50}$** | **$LC_{50}$** | **$LD_{50}$** | **$LC_{50}$** | **$LD_{50}$** | **$LC_{50}$** |
| Mallard | 0.26 | 2.0 | - | 158 | 3158 | 906 |
| Northern Bobwhite | - | 0.8 | 138 | 37 | >400 - <2000 | >5000 |
| Canada Goose | <0.75 | - | - | - | - | - |
| Black-backed Gull | <0.75 | - | - | - | - | - |
| Laughing Gull | 0.7 | - | - | - | - | - |
| California Quail | 3.3 | - | - | - | - | - |
| Ring-necked Pheasant | 10 | - | - | - | - | - |
| Harrier Hawk | 10 | - | - | - | - | - |
| House Sparrow | >6 | - | - | - | - | - |

a The $LD_{50}$ for an unknown bird species has been estimated to be above 0.56 mg/kg (see Howald et al. 2000)

The RQs for birds are presented in Figures 12, 13, and 14. The bird RQs exceed the EPA LOC of 0.5 for brodifacoum, and bromadiolone, falling below for diphacinone. This suggests that under the proposed alternative, if a bird was to be primarily exposed to the rodenticide, there is a risk of hemorrhaging and mortality.

The lack of interest in the placebo baits on Anacapa Island does not preclude the possibility of primary poisoning to landbirds. Field studies have shown that landbirds have been exposed to rodenticides that have been dispensed in both bait stations and by broadcast. Common Ravens, wekas and keas have been observed reaching into, or breaking into bait stations to gain access to the brodifacoum bait (Howald et al. 2000, Eason and Spurr 1995, Taylor and Thomas 1993). The primary exposure in combination with secondary exposure to brodifacoum had a significant

Figure 12. Risk quotients (RQ) for 20-50 g birds



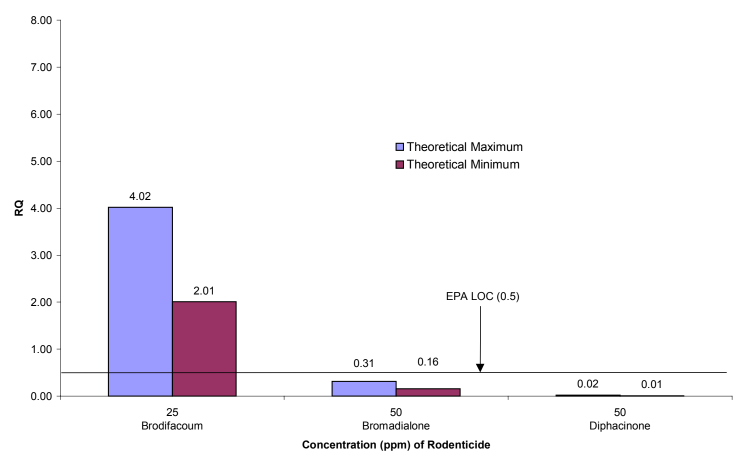

impact on the local populations. These species are large, aggressive and share an omnivorous diet which contributed to their decline. Primary exposure and some mortality of birds of varying sizes, foraging strategies and classifications including: Kiwi, South Island Robins, weka, North Island Saddlebacks, blackbirds, chaffinches,House Sparrows,H Sparrows, Australian Magpie, Paradise Shelducks, and Pukeko have been reported (Empson and Miskelly 1999; Dowding et al. 1999; Eason and Spurr 1995; Morgan et al. 1996). All were suspected or confirmed exposed to brodifacoum, applied both aerially and in bait stations, and used for rat eradications from islands. Although the above studies have documented exposures and some mortality of these species from rodenticide exposure, the significance of the extent of poisoning was varied ranging from significant mortality (Howald et al. 2000; Eason and Spurr 1995; Empson and Miskelly 1999), to minor and insignificant (Robertson et al. 1993; Robertson et al. 1999; Dowding et al. 1999; and Empson and Miskelly 1999). Although there were incidences of poisoning in most island eradications, some impacted species recovered to population densities which were higher than densities before rodenticide application. (Empson and Miskelly 1999; Robertson et al. 1999; B. Simmons, pers. comm.)

In summary, landbirds will be exposed to the rodenticides on Anacapa Island. The consequence of such exposure would depend on the rodenticide. Brodifacoum and bromadiolone would result in mortality to some individuals, through single and cumulative exposures. The risk of primary poisoning would be significantly less with the use of diphacinone.

### *Secondary Exposure (Indirect)*

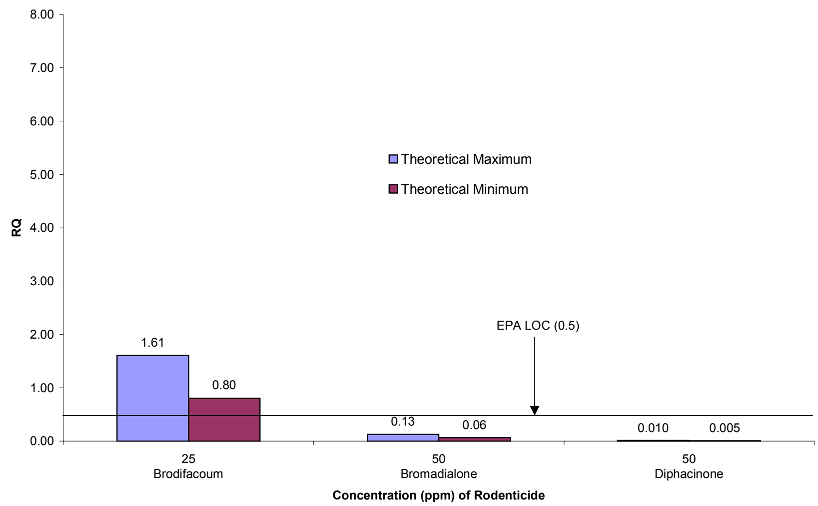
(*Pelagic Seabirds)* - The risk of secondary exposure to the pelagic seabirds is through consumption of primarily exposed fish. The

Figure 13. Risk Quotients (RQ) for 100-200g birds



…

Figure 14. Risk quotients (RQ ) for 500-1000 g birds




are at risk of secondary exposure through consumption of invertebrates that would have rodenticide residues in their digestive tract, however, the extent of this is believed to be relatively insignificant.

During the pre-eradication research, 11mice and 14 rat carcasses were observed for 165 hours to identify scavengers. The Common Raven and American Kestrel were the only landbird species observed to scavenge rats and mice (ICEG 2000). On Anacapa, only one pair of Common Ravens were observed, and American Kestrels were in low abundance, not even showing up in the bird surveys conducted in November/December 1999 (ICEG 2000). The birds of prey also were in low abundance, a maximum of 3 Burrowing Owls, 2 Short-eared Owls, and a pair of Barn Owls were observed on East Anacapa Island; Red-tailed Hawks and Northern Harriers were also in low abundance during fall surveys. This indicates that although there is a risk of secondary exposure to these species, the relative number of species present on the island during the proposed application period is low.

It seems reasonable to expect a significant impact on any species that preys primarily on rats and/or mice on Anacapa Island if brodifacoum is used. The relative risk would be less, although not absent with bromadiolone. The eradication of rats from East Island with a follow up on Middle and West Island may limit secondary poisoning because only a limited part of the island would be treated at any one point in time.

foraging grounds and the size of the prey would limit the potential for exposure. Most of the smaller seabirds take small prey such as sardines which would not be able to consume the bait pellets. The risk of secondary exposure to these species is very low.

(*Roosting Seabirds)* - Western Gull is the only species believed to be at risk of secondary exposure in the terrestrial environment via consumption of primarily exposed mice. No gulls were observed to consume any snap-trapped mice placed out in open areas, however, one was noted to pick up and drop a mouse carcass (ICEG 2000).

In the marine environment, if fish were to be extensively primarily exposed and were to float on the surface of the ocean, gulls would likely be an important scavenger that would consume the fish.

*(Landbirds)*- The birds of prey and scavengers are at risk of secondary exposure through predation/scavenging of live/dead mice and rats containing rodenticide residues (Table 17). Smaller landbirds such as the insectivores

Table 16. Occurrence of landbirds in the Channel Islands National Park and their foraging strategies.

| Island | Granivore | Omnivore | Insectivore | Carnivore | Total |
|---|---|---|---|---|---|
| AI | | 3 | | | 3 |
| SBI | 1 | 13 | 5 | 4 | 23 |
| AI and SBI | 3 | 53 | 14 | 8 | 78 |
| Other Islands | | 9 | 2 | 3 | 14 |
| Total | 4 | 78 | 21 | 15 | 118 |

The risk of secondary poisoning to predators/scavengers of rats and mice is limited by the availability of these prey in space and time. For the aerial predators on Anacapa, their search image is for live prey and thus risk of poisoning is during the latent period (after rats and mice have consumed the bait, but have not yet died) (estimated at 2 weeks). Anticoagulated poisoned rats and mice could be available to both diurnal and nocturnal predators and scavengers. On Anacapa, islet wide treatment would yield numerous dying rats and mice displaying erratic behavior and likely would be a significant prey base because of the ease of catching them. Similarly, a number of rats and mice would die above ground and available for diurnal scavengers. There would be extensive secondary poisoning of the birds of prey with the use of brodifacoum or bromadiolone. The risk of secondary poisoning would be significantly less, although present with the use of diphacinone.

*Mitigation*

It is recognized that the landbirds are at risk of primary and secondary poisoning. To minimize visual attractiveness to birds, and thus primary exposure, the bait would be dyed blue or green; colors known to be less preferred by the Passerines. Suggested mitigation measures to minimize or prevent exposure to the rodenticides could include: Live trap and release owls and diurnal birds of prey on the mainland, or live trap, hold in captivity until the risk period passes, and release birds of prey back on to island.

This mitigation would be difficult to implement because live trapping of specific individual birds can be difficult if not impossible (B. Walton, pers. comm., G. Howald, pers. obs.). If required to implement, efforts would be made, but no guarantees that all individuals would be removed. Similarly, removal of birds of prey from Anacapa, could result in more birds filling the empty territories potentially presenting a greater secondary poisoning risk because more birds would be present (B. Walton, pers. comm.).

An alternative approach may be to provide

Table 17. The birds of prey and scavengers of Anacapa Island at risk of secondary exposure

| Birds of Prey | Scavengers |
|---|---|
| Barn Owls | Common Raven |
| Burrowing Owls | American Kestrel |
| Short-eared Owls | |
| American Kestrel | |
| Northern Harrier | |
| Red-tailed Hawk | |

the landbirds with supplemental food which would be more attractive than the bait pellets and/or rodent carcasses. Supplemental feeding stations would have to be established and regularly maintained before, during and after the baiting period.

For those carnivorous species that would scavenge dead rodents, carcass searching could be carried out to find, collect and dispose of any dead rodents. Thus, secondary exposure via carcasses is minimized.

### *Sub-Issue 7 – Terrestrial Mammals*

#### *Primary Exposure (Direct)*

Toxicology - Acute oral toxicity data exists for mammals (Table 18). Brodifacoum is the most toxic rodenticide proposed under the alternatives.

Bait Composition, Delivery and Behavior - The presence of the deer mouse on Anacapa Island presents difficulties for eradication.

The baits are optimized for rodent control, and subsequently mice would be attracted to and would consume the bait. The impact on the mouse population would be heavy. The aerial broadcast of bait into the ecosystem increases the probability that any one individual mouse would be exposed to the bait, however, the exposure would be limited to a short window in time as bait would be removed from territories. However, it may not result in 100% mortality because rats have larger home ranges than mice (Howald et al. 1997) and are competitively dominant. Consequently, it can be difficult to simultaneously eradicate both species because the rats consume all the bait before the mice have access to it. If all the bait is consumed within the home range of an individual mouse, that mouse would then escape contact with bait (D. Veitch, pers. comm.). If on Anacapa, rats consume all the bait within an area larger than the home ranges of male deer mice on Anacapa Island (Howald et al. 1997), then the mice living in those areas would likely survive for some time without contacting bait.

The RQ indicates that brodifacoum and bromadiolone exceed the EPA Level of Concern of 0.5 (Figure 15). Diphacinone offers some protection to deer mice, assuming that the $LD_{50}$ for house mice is representative of the sensitivity of deer mice. Deer mice are at a high risk of poisoning after a single days feed on bait containing either brodifacoum or bromadiolone.

There would be a high impact to the mouse population.

#### *Secondary Exposure (Indirect)*

The risk of secondary exposure to mice is believed to be small. The only route of exposure would be through the ingestion of an invertebrate containing rodenticide residues, or through consumption of poisoned carrion. The low retention time of the rodenticides in invertebrates limits this exposure window. Alternatives 2, 4, and 6 would limit the temporal risk. Bait stations in the remaining alternatives would increase the probability of secondary exposure over time.

#### *Mitigation*

The endemic subspecies of the deer mouse on Anacapa represents a logistical challenge to eradication of rats. The proposed mitigation for mice is outlined in Chapter 2.

## *Cumulative Effects*

This section will analyze how each of the alternatives could have a cumulative impact to predators and scavengers through repeated exposures to the rodenticides, and the potential (non-toxicological) cumulative impacts to seabirds. Included is a summary of rodenticide toxicology issues from the Mainland of Southern California which could contribute to non-target impacts.

Table 18. Acute Oral Toxicity of Rodenticides to Mammals (LD50 mg/kg) (A dash indicates that no data is available) (adapted from Erickson 1999)

| Species | Active Ingredient (Rodenticide) | | |
|---|---|---|---|
| | Brodifacoum Alternative 2, 3 and 6 $LD_{50}$ | Bromadiolone Alternative 4 and 5 $LD_{50}$ | Diphacinone Alternative 6 $LD_{50}$ |
| *Norway Rat* | 0.26-0.56 | 0.56-0.84 | 2.3-7.0 |
| *Black Rat* | 0.65 [a] | - | - |
| *Laboratory Mouse* | 0.4 | 1.75 | 50-300 |
| *Vole* | 0.2 | - | - |
| *Dog* | 0.25-1.0 | 10-15 | 0.88-7.5 |
| *Coyote* | - | - | 0.6 |
| *Rabbit* | 0.29 | 1.0 | 35 |
| *Guinea Pig* | 2.78 | 2.8 | - |
| *Mink* | 9.2 | - | - |
| *Mongoose* | - | - | 0.2 |
| *Cat* | 25 | - | 14.7 |

a from Taylor 1993

### *Alternative 1 – No Action*

This alternative would utilize no rodenticides and therefore would have no potential for cumulative exposures.

### *Effects Common to Alternatives 2, 3, 4, 5 and 6*

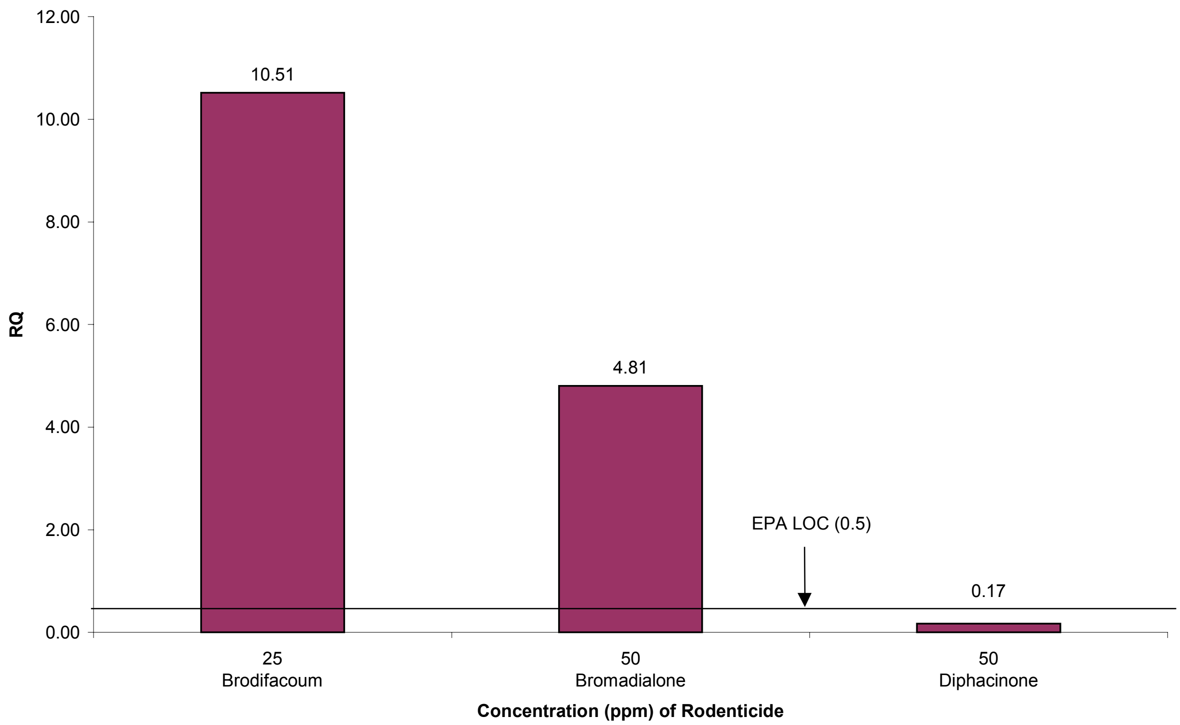
The use of brodifacoum or bromadiolone could result in predators and scavengers being exposed to the rodenticides through cumulative exposures. The properties of these chemicals (outlined above) are such that they are relatively insensitive to metabolism in vertebrate tissue which could result in accumulation of residues in time. The consequence of re-exposure is determined by how long after the initial application the bait is re-applied, the amount of area re-treated and the rodenticide in the bait. The 20 ha headland of Middle Island is not anticipated to be re-treated for up to a year after initial application. However, there may be a requirement for the re-treatment to protect East Island intermittently through the year. Any other areas treated initially would not be re-treated between one and two years after the initial application. This analysis is divided into primary and secondary exposure.

### *Middle Island Headland Re-Treatment*

#### *Primary Exposure*

Between each treatment, there will be enough time elapsed for degradation of any residual bait that may not have been consumed by the rats or mice, thus reducing primary risks between treatments to very low or negligible. This negligible period is expected to carry through the landbird breeding season, thus allowing birds to successfully breed before re-treatment may be

Figure 15. Risk Quotient (RQ) for a 20 g deer mouse.




necessary. As the rat population grows, and if they re-invade the headland, and the risk of re-invading East Island is deemed to be high, the treatment of the headland may be required. Thus, after treatment the primary poisoning risk would again be high, but not as high during the initial application because fewer rats would likely be occupying the territory and thus would not require as high a sowing rate to kill them all. The application period may cross over into the Western Gull breeding season and may result in primary exposure of gulls to the rodenticide. During the spring 2000 field trials, placebo bait, was not found to be attractive to gulls occupying nesting territories. This data suggests that although some gulls may be attracted to and consume bait, there will likely not be extensive primary exposure of gulls.

### *Secondary Exposure*

The risk of secondary exposure would be greatest during the initial application, and less with the subsequent re-applications because fewer rats and mice would be available as prey and there would be less bait placed into the environment. Similarly, if baiting of the headland occurs during the gull breeding season, there would be less overall risks to birds of prey on the islands because gulls harass the raptors generally excluding them from the island. During the spring and summer periods, very few, if any, birds of prey were observed and they were not detected during bird surveys. Some species, such as the Burrowing Owl and Short-eared Owl only overwinter on Anacapa Island, thus, they would not be present during the intervening months when the headland on Middle Island would be treated, thus escaping re-exposure. However, upon return to the islands, they may be at a greater risk of being lethally exposed to the rodenticide if they already contain sub-lethal levels of rodenticide residue in their tissues from exposure on the mainland. In other words, individuals could succumb to smaller and smaller amounts of rodenticides because of the sub-lethal levels in their tissues. This situation would be dependent on the availability of the rodenticide residues in time on the island. Re-application of an area could result in rodenticide residue being available in time which could lead to cumulative exposure.

Kaukeinen (1982) reported that no significant wildlife mortalities have been documented after 30 years of anticoagulant usage. Thus, the consequence of baiting would be restricted to non-target species that would be found on Anacapa Island. Migratory species that overwinter on Anacapa Island could potentially be exposed to the rodenticides on Anacapa, survive, and on return to breeding grounds on Mainland California, be exposed to the rodenticide and could succumb to the rodenticide exposure. The anticoagulant rodenticides have been detected in wildlife losses on Mainland California (B. Hosea, pers. comm.) and recently in golden eagles trapped on Santa Cruz Island (T. Coonan, pers. comm.). The detection of brodifacoum in golden eagles on the islands indicates that species with sub-lethal levels of rodenticide are transporting the chemical into the Channel Islands National Park from the mainland since no vertebrate pest control has taken place. With residues in their tissues they could be re-exposed to the anticoagulants on Anacapa Island, and succumb. The golden eagles are non-native species to the islands and are currently being removed from the islands (3-5 total remain). Only one golden eagle has been observed around East Anacapa Island (ICEG 2000). As time passes, the relative exposure risk would decline because limited bait would be applied in a relatively small area of land, at one point in time. On the mainland, the rodenticides are used for control and follow a chronic use pattern extensively around the state in both agricultural and urban settings.

### *Alternative 6*

The use of diphacinone under alternative 6 could represent a risk of poisoning to non-target species via the mechanism outlined above. The relative risk would be less than brodifacoum or bromadiolone because of the significantly lower residence time in vertebrate tissue.

### *Seabirds*

This project objective is to restore the island and as a consequence, free up seabird nesting habitat. Pressures on the seabird populations that utilize or could utilize Anacapa Island for breeding include oil spills and the squid fishery. The squid boats fish at night with high powered lights to draw in the squid for harvesting. The light boats cause increased predation to the adults and juvenile seabirds, and are known to negatively influence normal breeding activities (B. McIver, pers. comm.). Oil spills cause oiling of feathers which negates the insulatory properties of the feathers and leads to hypothermia and death. This section of the analysis will evaluate the cumulative effects to seabirds for each alternative.

### *Alternative 1 – No Action*

Under this alternative, the negative impacts of oil spills and light boat activities would continue. Together with the presence of the rats on Anacapa Island, the reproductive potential of the seabird population would be seriously hindered.

### *Effects Common to Alternatives 2-6*

Under these alternatives, rats would be removed from the island. The removal of the rats from the island should result in an increase in seabirds, particularly the Xantus' murrelet. The increased population could help offset some of the negative impacts from both oil spills and squid fishing. For example, if during the breeding season and the Xantus' murrelets were breeding in large numbers on both Anacapa and Santa Barbara, and a large oil spill occurred around either island, only one of the two populations of birds may be at risk of oiling (under the broad assumption that each population has a distinct foraging range away from each other). Compare with the occurrence of an oil spill around Santa Barbara Island, where a significant portion of the breeding population is at risk of oiling if rats were not removed from Anacapa. Similarly, the increased population of birds could help offset the potential impacts from predation due to light boats around the island. However, the presence of the light boats may also have a detrimental impact on the seabirds such that the seabird population could not grow even with the rats removed.

## *Issue 3: Public Safety and Visitation*

### *Introduction*

This section in the analysis will analyze the potential exposure of the general public to the rodenticides and how the proposed action would potentially impact visitors enjoyment to the park during the baiting operations. Within the exposure to the rodenticide section, the analysis will discuss how each method of delivery of the rodenticide may expose the visiting public to the rodenticide and associated health risks of exposure. Within visitor impacts, the effects discussion will focus on how the alternatives could potentially impact enjoyment of the park during operations.

### *Exposure to the rodenticide*

The different application methods of the rodenticides could potentially expose the visiting public to the rodenticide through primary exposure. However, it should be noted that this would need to be an intentional exposure on the part of the visitor, i.e., a person would have to seek out the bait and deliberately consume it. Anacapa Island is open to the visiting public year round. Visitors are allowed access to East Island and with permission, to West Island in Frenchy's Cove. Thus, primary exposure to the rodenticide is limited to these areas of the island. There is a small possibility that fisherman may catch fish that could contain trace amounts of rodenticide residue, thus, being secondarily exposed. This analysis is organized by application technique (aerial vs. bait station). A summary analysis outlining the health concerns associated with exposure is presented.

#### *Aerial Broadcast (Alternatives 2, 3, 4, 5, and 6)*

Each of the alternatives would use aerial broadcast either on the cliffsides or both the cliffsides and top of Middle and East Islands. The aerial broadcast of a rodenticide bait increases the probability that a bait is found in any one location on the treated area. However, the probability of finding a bait pellet would be small. Bait pellets are about 2 g in size, and would fall to the ground with enough force to be covered by vegetation and out of general sight.

The alternatives would restrict public access to the island 2-3 days during treatment. This closure period would allow for the rats and mice to consume the majority of the bait within 72 hours (ICEG 2000). The buffer areas around the buildings and campground on East Island would not be aerially treated, thus reducing the probability of finding the bait pellets even further because these areas attract the greatest number of visitors. Signs posted at the landing areas indicating that the island has been treated would

Table 19. Number of bait pellets for one $LD_{50}$ exposure to humans for each rodenticide [a]

| Age | Weight (kg) | Brodifacoum | Bromadiolone | Diphacinone |
|---|---|---|---|---|
| Adult | 70 | 364 | 392 | 1610 |
| Child | 10 | 52 | 56 | 230 |

a $LD_{50}$ defined as amount of pellets required for a 50% chance of lethal hemorrhaging . $LD_{50}$ assumed to be 0.26 mg/kg for brodifacoum, 0.56 mg/kg for bromadiolone and 2.3 mg/kg for diphacinone, based on $LD_{50}$ data for the Norway rat.

provide information about the program to visitors and warnings about the bait and to avoid it if encountered.

There is a risk of bait pellets drifting into the marine environment from aerial activity. The bait pellets may be consumed by fish and potentially representing a secondary poisoning hazard to fisherman consuming the catch. The likelihood of exposure is small, and significant exposure via this pathway is believed to be even smaller. The fish population studied did not consume any bait pellets, although sheephead was noted to chew and spit out the bait. The amount of residues found within the consumable flesh of fish would likely be of inconsequence relative to the amount required for measurable effects (Table 19). Only fish around Anacapa could be exposed to the bait, and of those only in the nearshore waters. There is a fishing restriction to 60 ft depth around the north shore of Anacapa, lowering the probability of rodenticide exposure to fisherman even further.

## *Bait Stations (Alternatives 3 and 5)*

In these alternatives, the use of bait stations around the buildings and campground on East Island would limit the potential for exposure to the rodenticides. The rodent bait would be encased within a lockable station that would be appropriately labeled "Rat Poison- Do Not Disturb". Pesticide labels attached to the stations would provide information as to the bait in the stations and emergency contact numbers would be provided as well as treatment for exposure. The stations would limit access to the bait to all but the most persistent visitors, such as those that may vandalize stations.

## *Consequence of Exposure*

The exposure to small amounts of the bait is considered to present a very low risk to humans. Warfarin, a relative of brodifacoum and bromadiolone, is a common antithrombin medication, administered to human patients as a drug to "thin" the blood preventing heart attacks and strokes. If sufficient amounts are consumed, exposure to either of the rodenticides would have the same effect as warfarin. In effect, "thinning" the blood. If too much was consumed, an antidote would be available. Treatment is through dietary or daily injections of Vitamin K1, a common and readily available vitamin. Studies have shown that workers handling brodifacoum, the most potent of the three rodenticides presented, over a 9 month period did not show any effects suggestive of significant exposure (ICI, in Taylor 1993).

To demonstrate the relative risks of exposure, the number of 2 g bait pellets required to consume one $LD_{50}$ for an adult and child is presented (Table 19).

## Summary

The probability of visitors exposed to the bait is extremely small. The probability of exposure would be limited by closing the island for 2 –3 days, allowing for the vast majority of the bait to be cleaned up by rats and mice. Posters would warn visitors of the application, and bait stations around buildings with pesticide warning labels. Additionally, it would be rather difficult for one to find and consume enough bait to be of any consequence. Effective medical treatment would be available because of the slow onset of toxicosis and availability of an antidote (Vitamin K1).

## Mitigation

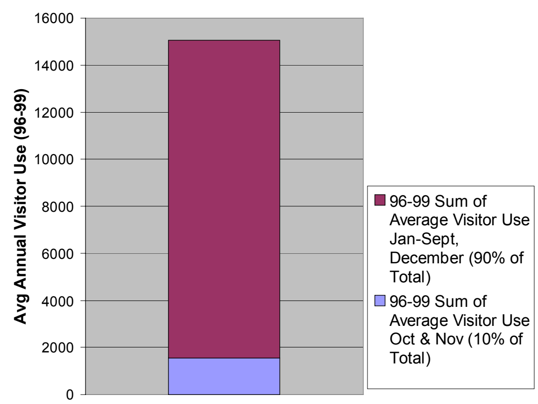
The bait could contain a bittering agent (bitrex) at a concentration known to deter human consumption, yet still be highly attractive to rats. However, there are data which suggest that bitrex could have a detrimental impact on eradications because some rats may be sensitive to the bittering agent (D. Veitch, B. Simmons, pers. comm.). The bait would be dyed a blue or green color that may be diluted out of the bait when exposed to water such as saliva and /or sweat making it a good indicator for someone who may have incidentally eaten or picked up the bait. Hospitals would be notified prior to the operation that anticoagulants have been used, and to not overlook symptoms of anticoagulant exposure.

Public areas on East Anacapa Island – trails, picnic areas and campgrounds would be inspected for any exposed bait, which would be removed before the island is open to the public. All employees and other park staff would be instructed about any hazards concerning the rodenticide before they are allowed on the island after application.

# Impacts to Visitor Enjoyment

Visitation to Anacapa Island is highest in the summer and lowest in the fall and winter periods. November and December are the slowest months with relatively minor numbers of visitors to the islands as compared to the peak season (Figure 16). The project plan would be to divide the islands into two sections, treating East Anacapa Island in year one and then Middle and West Island in year 2, thus always leaving one of the two public areas open to visitors at any one point in time. Similarly, the other Park islands would be open to visitors throughout the project period. Therefore, closure of the island for 2-3 day period post application would have no significant impact to visitor enjoyment.

Figure 16. Visitor use during proposed treatment period.



# *Sustainability and Long Term Management*

This section of the analysis will focus in on the relationship between local short-term uses of the environment and the maintenance and enhancement of long term productivity, irreversible and irretrievable commitments of resources, and adverse impacts that cannot be avoided. The analysis is divided into the no action alternative and rats eradicated (Alternatives 2-6) since the impacts across all alternatives will be similar. The difference between the alternatives would be the scale of impact to the resources.

<u>Relationship between Local Short-term uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity</u>

### *Alternative 1 – No Action*

Under this alternative, no short term uses of the Anacapa environment would take place. The Island would continue with normal Park operations as it has in the past. As a result, there would be no new existing short-term uses that would affect long term productivity.

### *Alternatives 2-6 – Rats Eradicated*

Under these alternatives, rats would be removed from the islands with the use of a rodenticide. The alternatives differ by rodenticide choice, intensity, and duration of application, however, the end result – rats eradicated - remains the same. The use of the rodenticides in the Anacapa ecosystem represents a risk of non-target poisoning to birds and mice causing reductions in population sizes. However, the actions would be of short duration which would result in short term declines of some species but those species would recover. Mitigation measures to minimize those impacts have been developed for landbirds. Deer mice have been appropriately protected from extirpation or extinction as outlined in Chapter 2. The benefit of rat eradication would be the recovery of the nesting seabirds, increased mouse populations, increased populations of intertidal invertebrates and terrestrial invertebrates. This increase in native species populations could potentially support greater numbers of those species that were incidentally poisoned with the rodenticide. In other words, the benefits outweigh the costs.

<u>Irreversible and Irretrievable Commitments of Resources</u>

The irreversible commitments are those which cannot be reversed, except perhaps in the extreme long term . An example, extinction of a species is an irreversible loss. Irretrievable commitments are those that are lost for a period of time, e.g., restriction of visitor use while an area is temporarily closed would be an ongoing irretrievable loss. The following describes irreversible and irretrievable commitments of resources resulting from affirmative actions identified in the various alternatives.

### *Alternative 1 – No Action*

Under this alternative, continued rat predation of seabirds would represent an irretrievable loss. An irreversible loss could be the lack of regeneration of the island oaks and cherries on West Island. Similarly, the financial commitment of the American Trader Trust Council would be an irreversible loss since the funds are dedicated towards seabird habitat restoration.

### *Alternatives 2-6 – Rats Eradicated*

Under each of the alternatives there would be no irreversible loss of resources. There would be irretrievable loss of resources, in particular, mice and landbirds. However, these resources are proposed for mitigation and protection before the operations would begin.

## *Unavoidable Adverse Impacts*

The impacts identified below for each alternative are those for which there are no mitigating measures or which could not be mitigated to a level of insignificance.

### *Alternative 1 – No Action*

The No Action alternative, by definition, contains no measures to mitigate impacts to resources. The presence of rats in the Anacapa ecosystem will continue to result in significant, unmitigated, adverse impacts to seabirds, landbirds, mice, invertebrates, and plants.

### *Alternative 2-6 – Rats Eradicated*

Under each of the alternatives, the level of mitigation should be sufficient for a level of insignificance.